

## CLAIMS

What is claimed is:

- 1 1. A free space optical apparatus, comprising:  
2 an optical fiber to propagate at least a portion of an incoming light beam; and  
3 a ferrule coupled to the optical fiber, wherein the ferrule includes a plurality of  
4 regions to direct one or more portions of the incoming light beam in one or more  
5 predetermined directions, an amount of light in each of the one or more portions  
6 being a function of an alignment between the incoming light beam and the  
7 apparatus.
- 1 2. The apparatus of claim 1, wherein at least one region of the plurality of  
2 regions includes a diffractive optical element.
- 1 3. The apparatus of claim 2, wherein the diffractive element comprises a surface  
2 grating.
- 1 4. The apparatus of claim 2, wherein the diffractive optical element comprises a  
2 hologram.
- 1 5. The apparatus of claim 4, wherein the hologram comprises a volume phase  
2 grating.
- 1 6. The apparatus of claim 2, wherein the diffractive element diffracts incident  
2 light so that substantially all the diffracted light is in a preselected order.

1 7. The apparatus of claim 2, wherein a first region and a second region of the  
2 plurality of regions each include a diffractive optical element, each diffractive  
3 element to diffract incident light so that substantially all the light diffracted by that  
4 diffractive element is in a preselected diffraction order, the direction of the  
5 preselected diffraction order of the first region being different from that of the second  
6 region.

1 8. The apparatus of claim 1, wherein at least one region of the plurality of  
2 regions includes a reflective facet.

1 9. A free space optical system, comprising:  
2 an optical fiber having a first end to receive at least a portion of an incoming  
3 light beam;  
4 a communications detector, coupled to a second end of the optical fiber, to  
5 receive the received portion of the incoming light beam via the optical fiber;  
6 a ferrule fitted to the first end of the optical fiber, wherein the ferrule includes  
7 a plurality of regions to direct one or more portions of the incoming light beam in one  
8 or more predetermined directions, an amount of light of each of the one or more  
9 portions being a function of an alignment between the incoming light beam and the  
10 system; and  
11 a plurality of tracking detectors arranged to receive the one or more portions  
12 directed by the plurality of regions.

1 10. The system of claim 9 wherein at least one of the plurality of tracking  
2 detectors is a photodiode.

1 11. The system of claim 9 wherein at least one of the plurality of tracking  
2 detectors is an avalanche photodiode.

1 12. The system of claim 9, further comprising collection optics arranged to  
2 redirect the portions directed by the plurality of regions to the plurality of tracking  
3 detectors.

1 13. The system of claim 9 further comprising a lens coupled to the first end of the  
2 optical fiber, wherein light directed toward a cladding of the optical fiber will be  
3 redirected to a core of the optical fiber by the lens.

1 14. The system of claim 9, wherein at least one region of the plurality of regions  
2 includes a diffractive optical element.

1 15. The system of claim 14, wherein the diffractive element comprises a surface  
2 grating.

1 16. The system of claim 14, wherein the diffractive optical element comprises a  
2 hologram.

1 17. The system of claim 16, wherein the hologram includes a volume phase  
2 grating.

1 18. The system of claim 14, wherein the diffractive element diffracts incident light  
2 so that substantially all the diffracted light is in a preselected order.

1 19. The system of claim 14 further comprising a mount having an opening aligned  
2 with the first end of the optical fiber, wherein the plurality of tracking detectors are  
3 attached to mount.

1 20. The system of claim 14 wherein the incoming light beam has a pedestal  
2 distribution.

1 21. A free space optical system, the system comprising:  
2 an optical fiber having a first end to receive at least a portion of an incoming  
3 light beam;  
4 a communications detector, coupled to a second end of the optical fiber, to  
5 receive the received portion of the incoming optical signal via the optical fiber; and  
6 a multi-cell optical detector coupled to the optical fiber so that the first end of  
7 the optical fiber is fitted to an opening of the multi-cell optical detector, the multi-cell  
8 optical detector being arranged so that an amount of light incident on a cell of the  
9 multi-cell optical detector is a function of an alignment between the incoming light  
10 beam and the system.

1 22. The system of claim 21, wherein the multi-cell optical detector is a quadrant  
2 detector, the opening being located at a point where the quadrant detector's cells  
3 meet.

1 23. The system of claim 21, further comprising a lens coupled to the first end of  
2 the optical fiber, wherein light directed toward a cladding of the optical fiber will be  
3 redirected to a core of the optical fiber by the lens.

1 24. A free space optical system, comprising:

2 a plurality of optical fibers, wherein the plurality of optical fibers include a first  
3 fiber having a first end to receive at least a portion of an incoming light beam, and  
4 having a set of fibers arranged about the first fiber, the set of fibers being shaped to  
5 substantially conform to at least a portion of an outer surface of the first fiber, the set  
6 of fibers having a first set of fiber ends arranged to receive light of the incoming light  
7 beam that is not incident on the first end of the first fiber so that an amount of light  
8 incident on each fiber of the set of fibers is a function of an alignment between the  
9 incoming light beam and the system;

10 a communications detector coupled to a second end of the first fiber; and

11 a set of tracking detectors, wherein each tracking detector of the set of  
12 tracking detectors is coupled to a corresponding fiber of the set of fibers, each  
13 tracking detector to detect any light propagated by its corresponding fiber of the set  
14 of fibers.

1 25. The system of claim 24 wherein at least one of the set of tracking detectors is  
2 a photodiode:

1 26. The system of claim 24 wherein at least one of the set of tracking detectors is  
2 an avalanche photodiode.

1 27. The system of claim 24 wherein the first end of the first fiber extends beyond  
2 the first set of fiber ends.

1 28. The system of claim 24, further comprising a lens coupled to the first end of  
2 the first fiber, wherein light directed toward a space between the fibers of the  
3 plurality of optical fibers will be redirected to a core of the first fiber by the lens.

1 29. The system of claim 24, further comprising a diffractive optical element  
2 disposed between a source of the incoming light beam and the plurality of optical  
3 fibers, wherein the diffractive optical element to redirect at least a portion of the  
4 incoming light signal to the set of fibers.

1 30. The system of claim 29, wherein the diffractive optical element includes a  
2 radial transmission grating with a non-diffractive region aligned with the first fiber so  
3 that light of the incoming light beam directed toward the first fiber will pass through  
4 the non-diffractive region and strike the first fiber.

1 31. A free space optical apparatus, comprising:  
2 a first optical fiber to receive at least a portion of an incoming light beam;  
3 a plurality of optical fibers not including the first optical fiber, wherein the  
4 plurality of optical fibers to receive light of the incoming light beam that is not incident  
5 on the first optical fiber; and  
6 a mounting plate having an opening to receive the first optical fiber, and  
7 having a plurality of grooves to receive the plurality of optical fibers.

1 32. The apparatus of claim 31, wherein the mounting plate has a refractive index  
2 that is substantially the same as that of the first optical fiber and the plurality of  
3 optical fibers.

1 33. The apparatus of claim 31, wherein the plurality of grooves are shaped to  
2 receive protrusions formed on ends of the plurality of optical fibers.

1 34. The apparatus of claim 31, wherein the plurality of optical fibers each have an  
2 angled tip that serves as a reflective surface to couple incident light to one of the  
3 plurality of optical fibers.

1 35. The apparatus of claim 31, wherein at least one groove of the plurality of  
2 grooves has sidewalls that constrain the location of one of the plurality of optical  
3 fibers.

1 36. The apparatus of claim 31, wherein the incoming light beam has a pedestal  
2 distribution.

1 37. A free space optical apparatus, comprising:  
2 an optical fiber having a first section and a second section, wherein the first  
3 section to receive at least a portion of an incoming light beam and wherein the  
4 second section to propagate an outgoing light beam; and  
5 a ferrule coupled to the optical fiber, wherein the ferrule includes a plurality of  
6 regions to direct one or more portions of the incoming light beam that are not  
7 incident on the optical fiber in one or more predetermined directions, an amount of  
8 light in each of the one or more portions being a function of an alignment between  
9 the incoming light beam and the apparatus.

1 38. The apparatus of claim 37, wherein each region of the plurality of regions  
2 includes a diffractive optical element.

1 39. The apparatus of claim 38, wherein the diffractive element comprises a  
2 surface grating.

1 40. The apparatus of claim 38, wherein the diffractive optical element comprises  
2 a hologram.

1 41. The apparatus of claim 40, wherein the hologram comprises a volume phase  
2 grating.

1 42. The apparatus of claim 38, wherein the diffractive element diffracts incident  
2 light so that substantially all the diffracted light is in a preselected order.

1 43. The apparatus of claim 38, wherein a first region and a second region of the  
2 plurality of regions each include a diffractive optical element, each diffractive  
3 element to diffract incident light so that substantially all the light diffracted by that  
4 diffractive element is in a preselected diffraction order, the direction of the  
5 preselected diffraction order of the first region is different from that of the second  
6 region.

1 44. The apparatus of claim 37, wherein at least one region of the plurality of  
2 regions includes a reflective facet.

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1 45. The apparatus of claim 37, wherein the incoming light beam has a pedestal  
2 distribution.

1 46. A method, comprising:



2 receiving an incoming light beam using an apparatus that includes an optical  
3 fiber and a ferrule fitted to the optical fiber, the ferrule having a plurality of regions;  
4 and  
5 propagating light of the incoming light beam that is incident on the optical fiber  
6 to a communications detector; and  
7 redirecting light of the incoming light beam that is incident on the plurality of  
8 regions of the ferrule to at least one of a plurality of tracking detectors, wherein each  
9 region of the plurality of regions redirects incident light of the incoming light beam to  
10 a corresponding preselected tracking detector of the plurality of tracking detectors.

1 47. The method of claim 46, wherein redirecting light of the incoming light beam  
2 comprises diffracting light that is incident on a region of the plurality of regions using  
3 a diffractive optical element.

1 48. The method of claim 46, wherein redirecting light of the incoming light beam  
2 further comprises reflecting light that is incident on a region of the plurality of regions  
3 using a reflective coating applied to that region.

1 49. The method of claim 46, wherein redirecting light of the incoming light beam  
2 further comprises using collection optics to redirect light from the plurality of regions  
3 to the plurality of tracking detectors.

1 50. The method of claim 46, wherein the incoming light beam has a pedestal  
2 distribution.

1 51. A method, comprising:  
2 attaching a multi-cell detector to an optical fiber to form an assembly;

3       arranging the assembly to receive an incoming light beam so that at least a  
4       portion of the incoming light beam is incident on a tip of the optical fiber and light of  
5       the incoming optical signal that is not incident on the tip is incident on the multi-cell  
6       detector, the amount of light incident on each cell of the multi-cell detector being  
7       dependent on an alignment between the assembly and the incoming light beam;  
8       propagating, via the optical fiber, light of the incoming light beam that is  
9       incident on the optical fiber to a communications detector; and  
10       adjusting the alignment between the assembly and the incoming light beam  
11       using output signals from the multi-cell detector.

1       52.    The method of claim 51, wherein the multi-cell detector comprises a quadrant  
2       detector.

1       53.    The method of claim 51, wherein the incoming light beam has a pedestal  
2       distribution.